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SPRAYING FOR THE ALFALFA WEEVIL

THIS BULLETIN, devoted chiefly to a description and illustration of the control of the alfalfa weevil by means of arsenical sprays, is intended for the man who is already well acquainted with the appearance of the pest and its effect upon his crop.

There are thousands of such farmers in Utah, Idaho, Colorado, and Wyoming, and their aggregate losses from this cause reach hundreds of thousands of dollars each year. The treatment described in these pages can be used throughout most of this territory and is suitable for both large and small acreages. It has been prepared during seven years of study and experiment and one season of thorough field trial in cooperation with farm bureaus, in the course of which over 4,000 acres were successfully sprayed by practical farmers, many of whom were without experience in any kind of spraying. The Farm Bureau News, of Sevier County, Utah, reports a saving of $15,000 by this means and estimates from other sources raise the total to $40,000.

Contribution from the Bureau of Entomology
L. O. HOWARD, Chief
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SPRAYING FOR THE ALFALFA WEEVIL.

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THE TURNING POINT IN WEEVIL INJURY DETERMINES THE TIME TO SPRAY.

THE BEST TIME TO SPRAY for the alfalfa weevil is determined by the progress of weevil injury in the alfalfa field. The seasonal activity of the weevil is as follows: The adult beetles or weevils, after hibernating in the fields, come out in early spring, feed sparingly upon the leaves and stems, and deposit eggs, at first in the softer dead stems on the ground and later in the green stems. The eggs develop slowly at first and faster as the temperature rises, until in May and June they hatch within two weeks after they are laid.

The feeding of the larvæ begins early in the spring and increases steadily until after the height of the hatching season in May, but the plants outgrow the injury until shortly before cutting time, when the young larvæ become so numerous that they completely destroy the growing tips and thus stop the growth of the plants (fig. 1). This is the *turning point in injury*, and after it is passed the appearance of the field changes rapidly; the leaves are consumed until nothing is left but woody fibers, and the tops of the plants are as white as if they had been frostbitten. This condition is shown in

figure 2. The injury spreads downward, and before the normal cutting time, if the field is allowed to stand, the whole plant is bare

FIG. 1.—The "turning-point" in alfalfa-weevil injury. The plant on the right is almost uninjured, that in the middle has reached the turning point, and that on the left is nearly destroyed.

of leaves and the green covering has been stripped from the stems. The feeding continues for two or three weeks longer and delays the growth of the second crop unless the larvæ are killed.

The *turning point*, then, coming from one to two weeks before the first crop is ready for cutting, is the best time to spray the field. The feeding larvæ are now most numerous and the conditions for poisoning them accordingly most favorable. On the other hand, the crop is not yet too badly damaged to recover quickly after the killing of the larvæ. Figure 3 shows the result of treatment at the proper time. The work may be done a week earlier or several days later, as the owner's experience and the character of the season may dictate. It has been done as early as April 20, entirely preventing damage to the crop, and in other cases it has been delayed until the plants had been stripped of their foliage, in spite of which they

FIG. 2.—A field of alfalfa which has passed the turning-point. The lower foliage is still sound, but the tops are white and the buds have been killed.

were able to recover and bloom. The early spraying, however, is uncertain, as its success depends partially upon poisoning the adult beetles, which feed but little, while late spraying allows the destruction to go too far and makes recovery too slow.

THE TIME OF THE TURNING POINT IS GOVERNED BY WEATHER CONDITIONS.

The time of the turning point varies from year to year with weather conditions. If the weevils were affected by these conditions in the same way as the alfalfa it might be possible to name a definite stage in growth of the plant at which spraying should be done, but this is not always true.

In warm seasons the plants get an early start, which tends to postpone the turning point, but since this is more than offset by the rapid development of the weevils the damage is likely to come early. An extreme case of this occurs when the season is dry as well as warm; then the drought retards only the alfalfa, while the weevils develop without hindrance, and check the growth while it is still too small for profitable handling. It is in such circumstances that spraying yields its greatest returns.

In cold, backward seasons the situation is the opposite of that just described. The growth of the plants is hindered by the weather, but not so much as the weevil's egg laying, hatching, and feeding, and

FIG. 3.—First crop ready to cut, ten days after spraying. The white area is an unsprayed strip.

the crop becomes nearly mature before its growth is halted. In the abnormally late season of 1917, when in Utah March temperatures were delayed 30 days, and April and May temperatures 15 days behind the normal schedule, the first crop was fully mature before any injury had taken place, and the result was the only good first crop since the introduction of the alfalfa weevil. At such times the effect of spraying upon the first crop is least pronounced, and its effect upon the second crop becomes the principal consideration.

A heavy frost during the growing season has but little effect upon the insect, merely delaying the egg laying, hatching, and feeding for a few hours, but it may seriously stunt the alfalfa plants and thus

put them at the mercy of the weevil larvæ, somewhat as does the cutting of the first crop. Spraying has been done in such cases, apparently with good results, but this is still a matter for experiment.

In the average season the conditions lie between those of the two extremes just described. The checking of growth occurs about 10 days before the first crop is ready to cut, and spraying at that time enables the crop to finish its growth. This fully repays the cost of the treatment and is one of the principal arguments for it, especially in districts where the scarcity of late water makes the first crop the important one.

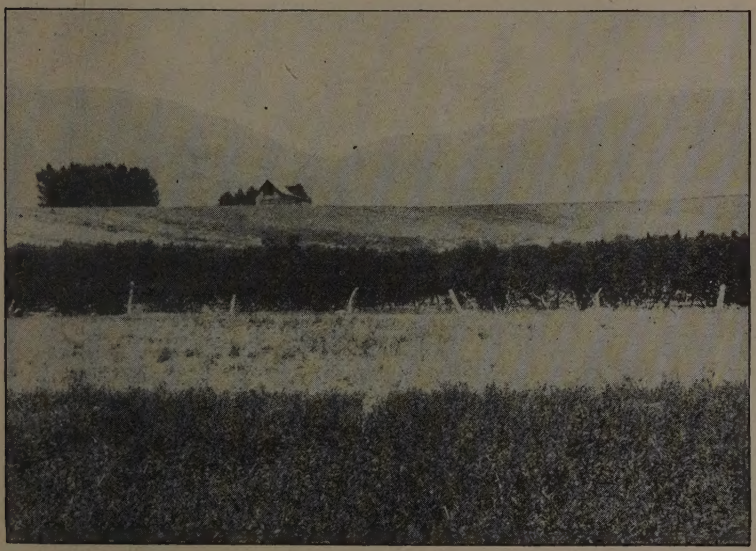

FIG. 4.—Second crop saved by spraying. The strip of bare stubble near the fence was left untreated at the spraying of the first crop.

SECOND-CROP PROTECTION.

In well-watered sections of the country, where a second crop can be grown, the profit realized by the first crop is only part of the results of spraying. The greater gain is in protection of the second crop, as shown in figure 4, from the larvæ which gather upon the small buds and prevent all growth during the three weeks or more that their feeding continues. Spraying produces a more uniform second crop than does brush dragging, as shown in figure 5. If the larvæ have been poisoned through spraying of the first crop, the second crop sprouts and grows without delay, and no treatment of the stubble is necessary.

STUBBLE SPRAYING NOT RECOMMENDED.

Stubble spraying has been successfully done by a number of farmers, but it requires getting upon the field immediately after cutting, which is not always possible, and further, a much larger quantity of liquid per acre is needed than if it were applied to the first crop. In years when the damage to the first crop is slight it might seem more convenient to cut it first and then spray the stubble, but the results of many trials show that this is not usually true. The time to poison the larvæ most easily is when they are feeding upon the tips of the first crop, and not when they are clustered below the surface of the

FIG. 5.—Brush-dragged portion of field shown in figure 4. The uneven growth is a characteristic result of this treatment.

ground upon the buds of the stubble. Stubble spraying can only be advised when earlier spraying has been impossible.

PREPARATION OF MACHINERY.

Before using spraying machinery it is necessary to overhaul and repair it. To make sure that the nozzles, hose, and connections, and the packing of valves, pistons, and cylinders are in good condition, the engine in working order, and the pump and pipes free from rust and scale, takes about three days, and should be done long enough in advance so that the necessary repairs will be finished in time. Spraying is less profitable if too much cleaning and repairing are left to be done after spraying begins, while the crew waits and the weevils destroy the hay crop.

If machinery must be purchased or hired and fitted for alfalfa spraying, it should be ordered months in advance. Local dealers in any community where people are beginning to spray for the alfalfa weevil are likely to have sold out their stock long before the season has begun.

NECESSARY EQUIPMENT.

The necessary equipment for spraying alfalfa consists of (1) a truck or vehicle; (2) a tank with an agitator; (3) a pump; (4) a pressure gauge; (5) an engine and pumping jack, unless the pump is to be driven by hand; (6) a strainer; (7) a boom or pipe, for distributing the liquid from the pump; and (8) spray nozzles.

FIG. 6.—A homemade spray outfit. No part of this equipment was originally designed for spraying. Even the nozzles were homemade. In convenience and utility it is equal to any spray machinery manufactured.

These essentials may all be contained in a barrel-pump outfit carried in a wagon, or they may be in the form of a 200-gallon tank mounted with a gasoline engine and pump on a special frame and truck. Any pump, with brass lining, valves, and pistons, capable of delivering four-fifths of a gallon or more per minute and maintaining a pressure of 75 pounds, can be used for this purpose on a scale suited to its size. Figure 6 shows a spray outfit which was assembled under difficulties from materials already on hand.

CAPACITY OF THE OUTFIT.

The size of the outfit should be adapted to the work it is to perform and can best be calculated by beginning at the nozzle and

taking up the various items in an order nearly the reverse of that in which they have just been mentioned. The best results have been obtained with nozzles working 2 feet above the alfalfa, each nozzle as it moves across the field spraying a strip 2 feet wide. A single nozzle in spraying an acre, which is 43,560 square feet, therefore covers a strip 2 feet wide and 21,780 feet long, or, in other words, travels 21,780 feet. It is now considered desirable to apply 100 gallons per acre, and in order to do so the nozzle must deliver 1/21,780 of that quantity to each linear foot of the strip; and as 200 feet per minute is an average walking gait for a team hauling the outfit, the nozzle must deliver 200/21,780 of 100 gallons, or 0.9 of a gallon per minute.

The same figures show that the time required to spray an acre with one nozzle is 21,780÷200, or 109 minutes. If twice as many nozzles are used the strip sprayed will be twice as wide and one-half as long, and the time required will be one-half as great; and so the time and the amount of driving required will vary as the number of nozzles is increased, but the rate of flow of each nozzle must be kept the same so long as the driving gait and the quantity per acre are unchanged.

Knowing the number of gallons with which each nozzle must be supplied per minute it is easy to compute the capacity required of the pump for a given number of nozzles, or the number of nozzles which a given pump will support. It is also possible to calculate how large an outfit will be needed to spray a given area in a given time, or how large an area a pump already on hand can spray in a given time, according as the controlling factor is the kind of pump which is available, the number of acres which must be sprayed, or the time which can be devoted to it. Thus 10 nozzles, each discharging 0.9 of a gallon per minute, will require a pump which can deliver 9 gallons in that time, and such an outfit will spray an acre in about 11 minutes of actual work. Such a machine is shown in figure 7.

The capacity of a pump depends upon the size of the plunger, the length of its stroke, and the number of strokes per minute, and can therefore be ascertained by a simple calculation. The area of the plunger is found by dividing its diameter, in inches, by 2, multiplying the result by itself, and that result again by 3.1416. This result, multiplied by the length of the stroke in inches, gives the contents of the cylinder in cubic inches, which is reduced to gallons by dividing by 231, and gives the quantity delivered by a stroke of the pump. If the latter is double-acting, as most of the better spray pumps are, this must be multiplied by 2. The delivery per minute is then obtained by multiplying the number of gallons per stroke by the number of strokes per minute.

One-cylinder pumps operated by hand are usually rated on the basis of 30 strokes per minute, and those driven by power at 50 strokes per minute. Duplex and triplex pumps are driven at a speed of 40 to 50 revolutions per minute, giving, respectively, 80 to 100 strokes per minute for the former and 120 to 150 for the latter.

If it is necessary to estimate the size of pump needed for a given kind of work the process is reversed; for example, it has just been shown that a 10-nozzle outfit applying 100 gallons per acre and traveling 200 feet per minute uses about 9 gallons per minute. To maintain this flow a power pump at 50 strokes per minute must deliver 9÷50, or 0.18 gallon per stroke. If it is a double-acting pump,

FIG. 7.—An excellent outfit adapted for alfalfa-weevil spraying by the Colorado Experiment Station in cooperation with the authors.

each stroke fills and empties the cylinder twice, and the contents of the cylinder must be 0.09 of a gallon or 20.79 cubic inches. The area of a 3-inch plunger is 1.5 by 1.5 by 3.1416, or 7.0686 square inches, and the length of stroke required to give a capacity of 20.79 cubic inches is therefore 20.79÷7.0686, or 2.9 inches. A 2½-inch cylinder would need to have a stroke of about 4¼ inches.

A triplex pump operated at 50 revolutions (150 strokes) per minute would need only one-third the capacity of a single-cylinder pump, 0.06 gallon. Calculation shows that this can be obtained with a 2¾-inch cylinder and 2½-inch stroke.

Table I gives the flow per stroke, in fractions of a gallon, of the common sizes of double-acting pumps.

TABLE I.—*Capacity of cylinders of double-acting spray pumps, in fractions of a gallon.*

Diameter of cylinder, in inches.	Length of stroke, in inches.			
	2½	3	4	5
2	0.068	0.082	0.109	0.136
2¼	.086	.103	.139	.172
2½	.106	.127	.170	.212
2¾	.129	.154	.206	.257
3	.153	.184	.245	.306

The smallest barrel pumps will hardly supply a single nozzle, and can only be used for small patches of alfalfa, while some double-acting hand pumps with 3 by 5 inch cylinders deliver as high as 9 gallons per minute, and therefore are capable of supporting 10 nozzles. Such a pump will spray an acre in about 11 minutes, if labor is available to keep it going at 30 strokes per minute. The same pump driven by a 2-horsepower gasoline engine at 50 strokes per minute will deliver 15 gallons per minute and easily supply 10 nozzles, each delivering 1½ gallons. This is 25 per cent above the requirements of an outfit moving 200 feet per minute and makes it possible to drive 250 feet per minute and spray an acre in nine minutes.

Modern orchard spray outfits are usually of the duplex or triplex type with small cylinders and short stroke, and are designed to give a comparatively small flow and high pressure. They are less suitable for alfalfa spraying than the older pumps with larger cylinders and longer stroke, designed for larger flow and lower pressure. Seventy-five pounds pressure is enough for successful spraying for the alfalfa weevil, although it is possible that a better distribution of the poison is obtained at a pressure of 100 to 125 pounds. Higher pressures cause needless wear and strain upon the machinery.

The necessary capacity of an outfit having been decided upon, it remains to select the parts to conform to it and to the conditions under which the work must be done. Capacity is not the only thing to be considered in selecting or assembling an outfit. The truck, tank, pump, engine, boom, and nozzles can be chosen in such a way as to avoid later trouble and expense.

THE VEHICLE.

Almost any kind of wagon or truck can be used to haul the equipment. For a light outfit an express wagon or an ordinary farm wagon, preferably with no sides, is satisfactory. If planks are used for the bed, the engine, pump, and jack can be bolted to one of them. If an ordinary wagon box is used, a plank to which the machinery is bolted can be slid into it lengthwise and nailed or bolted down.

For a permanent structure a frame of 4 by 6 inch timber may be fitted to the wagon and a 200-gallon tank mounted with the other machinery upon it. The most convenient homemade truck is a flat rack. Commercial orchard spray trucks, usually furnished with low wheels and broad tires, may be used, but high wheels are better for spraying tall alfalfa, not because they break down less alfalfa, since this is only temporary, but because they make it easier to attach the spray boom at the proper height, and cause less jolting of the machinery in driving over rough ground.

THE TANK.

Commercial spray tanks are usually in the form of a half cylinder, made of redwood, cypress, or steel, with a capacity of 200 gallons. Homemade tanks are usually 50-gallon barrels, four of which, with an engine and pump, can be carried on an ordinary wagon or a flat rack. Two hundred gallons of water is load enough for a team in most fields. If the water has to be hauled a long distance a second team and a thrasher tank should be used for that purpose instead of the spray outfit.

The most important item connected with the tank is the agitator. Since the poison is not dissolved in the water, but merely mixed with it, it will gradually settle to the bottom of the tank, leaving only a weak mixture to be applied to the plants, unless the liquid is stirred constantly and vigorously. For this purpose commercial outfits use a paddle or propeller within the tank, operated by a shaft, sprockets, belt, or drive rod from the pump or jack. In barrels the liquid can be stirred by a paddle or dasher worked by the jack or pump or by hand.

A strainer of 20-mesh brass or bronze screen should be fitted over the opening through which the water enters the tank and another over the outlet from it which leads to the pump. The former may be at the end of the suction hose, if one is used for filling the tank. If a cloth cover is used to keep the tank or barrels from slopping over it should be of canvas rather than burlap or any other linty fabric.

THE PUMP.

In spray pumps of all sizes certain structural features are important because of the corrosive nature of the liquid and the need of a uniform flow at comparatively high pressure.

The cylinder lining, plunger, valves, valve seats, and other working parts in which a close fit is required, and which also come in contact with the arsenic, must be of brass, bronze, porcelain, or some other substance which is less rapidly corroded by the chemicals than are iron and steel. To maintain the pressure without waste of power

requires carefully fitted valves and properly packed stuffing boxes. All commercial spray pumps are built in this way, but pumps which were intended for other purposes should be refitted when used for spraying.

The suction hose leading from the tank to the pump should be 1 inch in diameter, with a heavy wall to prevent collapse. About 10 feet of it is needed.

Every engine-driven outfit must have a relief valve near the pump, permitting the surplus flow to return to the tank. This regulates the pressure and also acts as a safety valve to prevent the development of dangerously high pressures when the outlet is purposely or accidentally closed.

The pump must have an air-pressure chamber large enough to keep the flow steady and thus insure even distribution of the poison. Its capacity in gallons for a double-acting or duplex pump should be about equal to the number of gallons per minute discharged by the pump, which is much more than the capacity of the chamber usually furnished with force pumps and even of many spray pumps which are intended to be used with a smaller number of nozzles. Triplex pumps need air chambers only two-thirds as large. The pressure chamber should be attached to the line near the pump, but not between it and the relief valve, and it should be mounted in a vertical position to enable the settlings to drain out. It is best to provide the pipe leading to it with a check valve to retain the pressure in the chamber without strain upon the pump.

A cut-off should be inserted between the pressure chamber and the strainer (described below), to prevent loss of pressure during short stops. A plumbers' stop-and-waste cock is suitable for this purpose because it opens and closes with a single motion. The two ends are not alike, and it must be attached so that the closed end is toward the pump when the cock is turned off.

THE PRESSURE GAUGE.

A pressure gauge is necessary for good work with either a large or small outfit, because it is impossible without it to maintain the even pressure which is indispensable for the uniform spread of the poison. The gauge should be attached to the air-pressure chamber, or near it, and at a distance from the relief valve and the nozzles.

THE STRAINER.

Clogging of the nozzles by rust, scale, and fibers from the interior of the pump and the pipes can be prevented by inserting a strainer, so constructed that it can be cleaned easily, at some convenient place

in the pressure line beyond the cut-off (fig. 8). A $1\frac{1}{2}$-inch T is used as the shell, and the pipe from the pump is screwed into its middle opening. The T is turned so that the other two openings point up and down and a plug is screwed into the lower opening whence it can be removed to clean out the strainer. The strainer itself is a cone of 20-mesh brass or bronze screen strengthened by crossed hoops of No. 14 galvanized wire, both soldered to the inside of a $1\frac{1}{2}$ by $1\frac{1}{4}$ inch bushing, which is then screwed into the upper opening of the large T so that the cone points down into the T. This bushing is connected by suitable bushings with the hose leading to the boom. The spray

FIG. 8.—Pressure strainer attached to spray outfit.

liquid from the pump enters the shell at the side opening and flows upward through the screen cone and out at the top toward the nozzles, leaving the dirt on the outer lower side of the cone, from which it can be removed after taking out the bottom plug (fig. 9).

THE ENGINE.

The capacity of the gas engine should be about 1 horsepower for each 4 gallons per minute pump capacity. The power is transmitted to the pump through a jack, driven by a belt or gears, which should give a gear reduction of about 10 to 1. Some spray pumps are built with a crank shaft or eccentric shaft, which takes the place of the jack.

THE BOOM.

The boom which carries the nozzles and supplies them with liquid from the pump is made of 2-foot pieces of ½-inch galvanized-iron

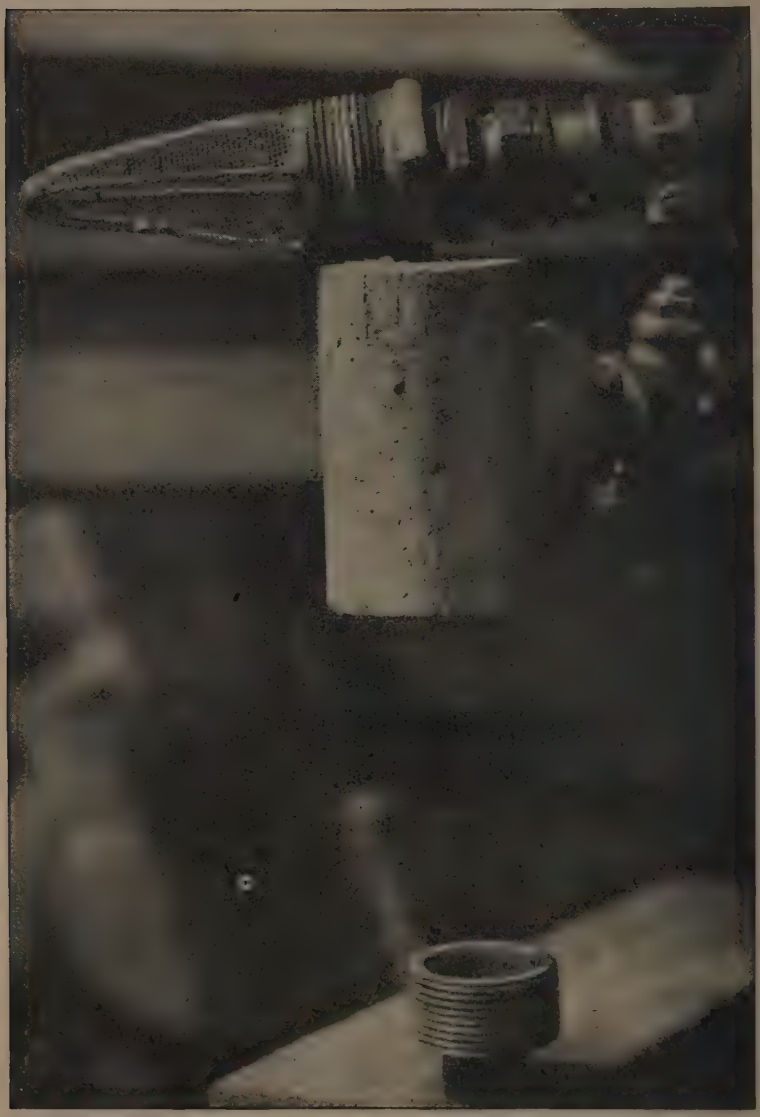

FIG. 9.—Parts of strainer shown in figure 8.

pipe, joined by tees, each of which affords an opening for the attachment of a nozzle. The boom may be all connected in one piece, in which case a cross must be used in place of one of the central

tees to allow for the hose connection with the pump, or it may be built in two independent halves, each swung separately from the frame of the vehicle and supplied by a separate pressure hose from the pump. In case the pump has but one lead and another is desired, it may be provided by adding a T or a Y. The divided boom is more convenient than the other for driving through gates and, the parts being shorter, is less likely to be broken on rough ground.

The boom is connected with the pump by a ½-inch, 5-ply or 7-ply pressure hose, to which it is joined by a hose coupler having a ½-inch pipe thread on one end and a ¾-inch hose thread on the other. The attachment of the nozzles to the boom is provided for by fitting each T with a ½ by ¼ inch bushing and a ¼-inch nipple about 1½ inches long, which fits the ¼-inch female thread of the nozzle.

The boom, whether in one piece or two, should not be expected to support its own weight. The best support is a 2 by 4, clamped or hinged to the truck, with the boom stapled, bolted, or wired to it. This prevents the slender pipe from whipping and breaking at the threads. The one-piece boom must be attached so that it can be quickly unfastened and removed when the outfit is driven through a gate. An advantage of the 2-piece boom is that the wings can be hinged so as to swing out of the way.

Twenty feet is the limit of length for the spray boom, owing to the amount of swinging at the ends caused by the wheels of the truck when moving over rough ground. Even when a shorter boom is used it is best to keep on hand one or two extra tees and sections of pipe to repair accidental breaks.

THE NOZZLES.

Plain nozzles, designed to give a misty spray, sometimes called hollow-cone, eddy-chamber, cyclone, whirlpool, and cover-spray nozzles, without strainers or other complications, are best for this work, since the purpose is to place a fine, even coating of poison upon the upper foliage, where the larvæ chiefly feed. This kind of nozzle has a base threaded to fit a ¼-inch pipe. On the other end is screwed a brass cap which holds in place the steel discharge disk with its central discharge opening, and back of that a gasket ⅛ inch thick, within the circle of which is the eddy chamber or whirlpool chamber, which breaks the jet of water into a hollow cone of fine mist and gives the nozzle its various names. Back of this space is the directing disk, a flat piece of metal pierced with one or two holes situated midway between the center and the edge and slanted so that the liquid passing through them gives a whirling motion to the contents of the eddy chamber. This disk should be removable from the body of the nozzle for cleaning, but it

is sometimes a part of the single-piece shell. For alfalfa spraying it should not have a central direct hole such as some orchard nozzles have.

The rate of flow of a nozzle depends upon many details of size, shape, and design, but in nozzles of the same pattern it is governed by the size of the discharge opening and the pressure supplied by the pump. Thus a certain nozzle which is in common use, when provided with a five sixty-fourths-inch opening and a pressure of 125 pounds, delivers a little more than four-fifths of a gallon per minute. For each additional 25 pounds of pressure the flow is increased one-sixteenth gallon. The same nozzle with a six sixty-fourths-inch opening delivers as much liquid at 75 pounds as with a five sixty-fourths-inch opening at 150 pounds, and increases one-eighth gallon for each added 25 pounds.

The discharge disk must be renewed occasionally, because the continued friction of the liquid wears away the edges of the opening, enlarging it and increasing the rate of discharge so that the material is wasted and eventually it becomes impossible to maintain the proper pressure.

There is some difference of opinion as to whether the nozzles should point directly downward or slant backward. The writers have tried various angles and failed to find any advantage in one position over the others.

The character of the spray produced by a plain nozzle of the type described in the foregoing paragraphs depends principally upon the pressure. With pressures below 75 pounds many of the particles of spray are so large that they roll down the surfaces of the foliage, collect in drops, and fall to the ground. At 75 pounds pressure the particles remain separate long enough to dry and form a fairly even coating, and as the pressure increases the spray becomes finer and the cover more nearly perfect. As the success of the work depends largely upon covering as nearly as possible all the upper foliage, the pressure should not fall below 75 and might well be kept at 100 to 150 pounds.

TOOLS.

The tools needed in fitting up and using a spray outfit are, in addition to the usual hammers and wrenches, two 12-inch or 14-inch Stillson wrenches and a pair of pliers. The cutting and threading of the pipe used for the boom can be done at a plumber's shop more economically than by buying the tools which would be required for doing the work at home.

THE POISON.

Arrangements should be made for obtaining the poison at the time when the machinery is being purchased or overhauled. Ar-

senate of lead and arsenite of zinc have been used on a large number of fields with complete success, and it is likely that other arsenical poisons which are recommended for orchard spraying are equally good. There is practically no danger of burning the foliage of alfalfa, and therefore the range of suitable poisons is larger than in fruit-tree spraying. The principal considerations are the cost of the poison and its capability for sticking to the leaves, and in both these respects arsenate of lead is slightly superior.

The dry, powdered form of the poison is better than the paste, because it costs less to ship and keeps better from year to year.

The poison is made much more effective by adding soap to make it spread more readily and stick to the leaves, which are so hairy that the particles of spray tend to collect in larger drops and run off.

The poison is weighed or measured for use at the rate of 2 pounds of the powder or 4 pounds of the commercial paste for each 100 gallons of water, and is stirred with a little water in a pail until it becomes a thin paste without lumps. It is then diluted and strained into the tank through brass milk-strainer gauze, which may be mounted for the purpose on a hoop or a frame which fits the opening in the tank. Two pounds of laundry soap for each 100 gallons is added.

The materials and utensils should be kept free from dirt and lint, which might later cause clogging of the nozzles, and when cloth is used for straining liquids or covering containers it should be canvas or muslin and not a linty fabric like burlap. The spray liquid should be mixed just before use and kept stirred up until it is all used, to prevent the settling and wasting of the poison and the clogging of the pipes.

APPLICATION OF THE SPRAY.

The spray outfit is ready for work when the tank, pump, pipes, and nozzles have been cleaned and, together with the engine, tried and found to be in working order and regulated so as to deliver 100 gallons of spray mixture per acre and maintain a pressure not lower than 75 pounds.

The weather most favorable for spraying is at the beginning of a warm period, because in warm weather the larvæ feed more freely and it is desirable to have them do so for several days immediately after the application of the poison. If it is put on just before a cold spell the weather may cause some of the feeding to be postponed until the alfalfa has grown a few inches and provided fresh unpoisoned food for the larvæ. Nevertheless, good results have usually been obtained in spite of unpromising weather, and all that is necessary is to give the poison a chance to dry thoroughly upon the foliage before it is exposed to storms.

One man is needed to drive the team and another to operate the machinery, if a power outfit is used. The number of men needed with a hand pump depends upon its size; the smaller pumps can be worked by one man, but the larger ones require two men or even three, each working two-thirds of the time.

Twenty-five acres can be covered easily in a day with a 10-nozzle machine, and this speed, with the low cost and the protection given to both crops at one operation, makes the spraying method superior to all others for the control of the alfalfa weevil. The actual cost is about $1 per acre, and growers who did the work for their neighbors in 1919 charged from 75 cents to $2, in addition to the cost of the poison, which was 60 cents per acre.

The results of the work begin to appear in about three days, and many dead larvæ can then be found, but the full effect is not obtained until the fifth day. By that time from two-thirds to nine-tenths of the larvæ have perished and the field takes on a brighter green. Remarkable contrasts are often produced by leaving a small strip unsprayed, as shown in figure 3.

DANGER OF POISONING STOCK.

There have been many inquiries as to the danger of poisoning live stock by feeding sprayed hay, which are all answered by the fact that such hay is shown by analyses and feeding tests to contain too little poison of any kind to injure farm animals. Many of the cattle which are fed upon it probably take in more arsenic with their drinking water than with their hay, and as for the lead content, few of them would under any circumstances live long enough to show the least effect of it.

CONCLUSION.

Seldom has any newly recommended method of insect control been so thoroughly safeguarded against failure as alfalfa weevil spraying. It has been tested every season for seven years, and the conditions necessary to success have been carefully ascertained. It is believed that most of the difficulties have been provided against, and it is certain that the farmers who tried it in 1919 are satisfied. The cost of the operation is trifling compared with the returns. Improvements will doubtless be made in the machinery and the arsenical poisons, but the method is at present a practical success, and no farmer in the territory infested or threatened by the alfalfa weevil can afford to overlook it.

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